Project Report: Extraterrestrial Impact History on Earth

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Project Progress

Field studies in the Barberton greenstone belt, South Africa , were conducted in June and July 2003 by Prof. Donald R. Lowe, Stanford University , and Prof. Gary Byerly, Louisiana State University , on 1) the Archean impact record, especially very large impacts; 2) Archean komatiitic volcanism; and 3) surface processes on the Archean Earth. In addition, Lowe and Byerly led a field conference for 29 invited international scientists June 23– July 2, 2003 , in the Barberton belt. This conference was sponsored by the NAI and partially supported by the UCLA NAI program. Among the key issues addressed during the conference were the relative roles of biological and abiotic (hydrothermal) processes in forming carbonaceous matter and siliceous sediments in the Barberton and similar early greenstone–belt sequences. Byerly has concentrated on: 1) refinement of field mapping, stratigraphy, and geochronology of the Barberton greenstone belt; and 2) examination of the Barberton ironstone pods, including field relations, mineralogy, and geochemistry. We have isolated zircons from several critical horizons, one a possible new impact layer, and one that will provide important constraints on the rates of deposition of black cherts. These samples should be dated this year using the Stanford Sensitive, High–Resolution Ion Microprobe (SHRIMP) facility. During the academic year, progress was made in writing and publishing the results of our environmental studies, and Mrs. Alexandra Krull Davatzes, a Stanford PhD student, began writing chapters in her thesis dealing with Archean impacts and impact processes. She has submitted one paper to Geology dealing with the condensation mechanics of rock vapor plumes formed by large meteorite impacts. Louisiana State University (LSU) PhD student Keena Kareem, is nearing completion of her work on these komatiites – several highlights are listed below. Two new LSU students are beginning work, including one that will focus on near–surface Archean alteration, especially carbonation of komatiites.

Frank T. Kyte, UCLA, has carried out analytical work on the geochemistry of sediments from several known impact and extinction horizons ranging in age from late Pliocene (2.4 Ma) through early Archean (3.5 Ga). This has included work on sediments from mass extinction events at the Permian–Triassic, Triassic–Jurassic, and Cretaceous–Tertiary boundaries. An important project

concluding this year has been characterization of impact deposits from one of the late Eocene impact events. Previous work on the late Eocene provided strong evidence of increased flux of interplanetary dust during the late Eocene, which might be caused by a comet shower from the Oort Cloud at the outer fringes of the solar system. Our latest work shows that the Cr−isotopic signature from a late Eocene impactor is consistent with a source from a main−belt asteroid compositionally similar to ordinary chondrites. We suggest that the increased dust flux might be related to numerous asteroid collisions following a major breakup event in the asteroid belt.

Highlights

- Studies of the thickest Archean spherule bed in the Barberton belt by Alexandra Krull Davatzes, PhD student at Stanford, shows that the impactor was about 40−50 km in diameter and the resulting rock vapor cloud evolved as it condensed, with more refractory, bolide−derived components tending to dominate the earliest condensates and more basaltic, target−derived components tending to dominate later condensates.
- Studies of the chromium isotope composition of iridium−rich impact spherules indicate that one impact in the late Eocene was likely by an asteroid disturbed from the main belt. This is generally inconsistent with earlier hypotheses that late Eocene impacts were caused by a comet shower.
- Ironstone pods, previously interpreted as sites of Archean seafloor hydrothermal vents, were reinterpreted by Lowe and Byerly as Modern subaerial vents. This work was discussed on the Nature website and will likely be controversial for some time. It has implications for the nature of Archean sedimentation, environments and early life.
- Keena Kareem’s work on komatiites from the 3.3 Ga Weltevreden Formation shows them to be remarkably well preserved, with fresh olivine and melt inclusions. They also appear to have erupted at unusually high temperatures, nearly 1700C, and moderately high oxygen fugacities, above QFM. They are nearly chondritic in many respects, but oxygen and lithium isotopes suggest complexities that may provide interesting constraints on Archean tectonism and mantle recycling.

Roadmap Objectives

- ***Objective No. 4.1:*** Earth's early biosphere
- ***Objective No. 4.3:*** Effects of extraterrestrial events upon the biosphere